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ABSTRACT

An international conference was held to allow experts from Japan, Europe, and the United States to share their views and experiences concerning the role that computers should play in higher education. The recommendations of the conference members are summarized here. First an introductory section provides an overview of educational technology, computer use, and international cooperation. The specific recommendations as to goals and aims, curriculum development, hardware implications, software considerations, and information exchange are then listed in some details. (JY)

centre
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THE USE OF COMPUTERS IN HIGHER EDUCATION

PERSPECTIVES AND POLICIES

technical report

OECD ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

ORGANISATION FOR ECONOMIC
CO-OPERATION AND DEVELOPMENT

Paris, 16th June, 1971
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and Innovation

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SEMINAR ON THE USE OF COMPUTERS
IN HIGHER EDUCATION

held in Portland, Oregon (USA)
from 26th-30th October, 1970

(Joint Project CERI XI)

PERSPECTIVES AND POLICIES

Recommendations of the Seminar

TABLE OF CONTENTS

PREFACE

It is no small event that the use of computers in education should have been included in the Programme of Work of the OECD Centre for Research and Innovation in Education from the very moment it began its activities in 1968. The growing demand for education necessarily calls for changes in structure, content and methods. In this so-called "mass media" age, with society becoming increasingly information-oriented, it would be idle and even dangerous to overlook the new teaching media, which not only of course include audio-visual aids but computers as well.

This is all the more true as computer science and the tools it uses are the key factor of growth in contemporary society, and are even more bound to be tomorrow. Each area of human activity is gradually being invaded by computer technology, whose effects can daily be felt. Education is one of the very few sectors which are still holding out or which at any rate have so far proved relatively impervious to such an intrusion.

The reasons for education's resistance are highly diverse. Some argue that the educational structures are at fault, pointing out that their rigidity is irreconcilable with innovation and change. Others maintain that the people themselves are to blame, meaning the teachers who are accused of using their "know-how" as an intangible asset without realising that the most important part of teaching is the learning side and that any educational system should first concentrate on the needs of students. Such an attitude, however, would be unfair - we have placed too much faith in "miracles" and praised "technological" solutions too highly not to realise that in the light of events the true shape of things is much more complex. Not only is the tool - in this case the computer - far from ideally suited in dealing with the constraints and requirements of the educational process, but the cart has often been put before the horse - we have started by trying to adapt steps in the learning process to the computer whereas the computer should have been adapted to educational objectives.

Much, therefore, remains to be done, which is why in 1969 the OECD Centre for Educational Research and Innovation launched a multinationally concerted action on the use of computers in education. The aim of this "joint project" is not to promote experiments for their own sake but to use them as the basis for a study on policy, whereupon the CERI should be able to lay down the lines which research and development should take if it is proposed that the computer should play its

role in the educational process to the full. The five universities(1) co-operating in this joint project form the nucleus of action extending far beyond the experimental stages.

For this reason - again with a view to determining together what sort of policy on computer utilisation in education should be adopted - the CERI has made every effort to co-operate with the authorities and research staff of OECD Member countries. This in no way means that various policy alternatives are unacceptable or that the particular context may not allow different methods of approach. The important thing must instead be to show the several paths of progress which can - and should - be taken.

To confront the views and experiences of a number of highly qualified experts was therefore considered necessary. It was also desirable to include the United States, since this is the country where computer science has made the greatest advances, in education as elsewhere. This confrontation is the first step towards a co-operative process promoting the transfer of technical and educational information as well as know-how.

The Seminar was organised by the U.S. Office of Education and the Northwest Regional Educational Laboratory in conjunction with the CERI. It was made possible by a subsidy granted by the National Science Foundation, and took place at Portland, Oregon, from 26th to 30th October, 1970. It was attended by some 15 Japanese and European experts and by about 10 from the United States. The final recommendations of the Seminar are attached herewith.

This initial concerted effort had the direct support of the national authorities of the Member countries concerned. The recommendations adopted undoubtedly herald action of far wider scope. Some may claim that educational objectives have been stressed at the expense of technical requirements, yet this is surely no cause for complaint by any one who realises that the machine, however powerful and sophisticated, is but a means and not an end.

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(1) The five universities are:

- University of Cambridge (United Kingdom), Department of Applied Mathematics and Theoretical Physics (Professor G.K. Batchelor);
- Université de Paris VII, France, The "Computer for Students" Laboratory, Teaching and Research Unit "Didactics of Scientific Disciplines"(Professor Y. Le Corre);
- Free University of Louvain, Belgium, General Physics Laboratory (Professor A. Jones);
- Rijsk University, Leiden, Netherlands. The Pedagogic Institute (Professor L. de Klerk);
- University of Osaka, Japan, Department of Educational Sciences of the Faculty of Letters, (Professor S. Tanaka).

INTRODUCTION

1. Educational Needs and Educational Technology

There is a growing awareness that the needs of education are not being satisfactorily provided for. Some of these anxieties are positive and clearly focused on particular educational requirements and objectives. Others reveal a state of frustration with the present methods for meeting the needs, and suggest that existing educational institutions are inadequate or improperly formed with respect to today's requirements. It is important to distinguish between the processes of education and the existing institutional mechanisms for delivering education. Educational needs are no longer confined to the limited age span that has traditionally been used to define formal educational provision, nor are they as homogeneous in requirements as they have been in the past. The multiplicity of educational reforms on a national scale gives evidence of the pressure for changes in the way educational institutions are designed and the way in which their programmes are formed. Educational planning today has to involve all aspects of a society and a critical problem is how to integrate the separate and often conflicting requirements and efforts into co-ordinated programmes. In addition, it is important that the newly formed approaches and mechanisms are designed to be responsive to continuous change. This is the challenge of educational technology, and its development must be conceived and designed in terms of how it may best play a significant part in bringing about programmes of innovation on a widespread and co-ordinated basis. An important aspect of this new technology is the use of the computer, which if properly deployed can play a key role in integrating and catalysing the effort. For these reasons it is especially appropriate and important for educationists, both nationally and internationally, to consider the proper approaches and procedures for its development as an educational resource.

2. Expectations and Results

The promise of educational technology has not been fully realised. The complexity of the problems of education are such that it is unrealistic to assume that they can be rapidly solved through educational technology. While substantial progress has been made it has been most substantial in the definition of the problems currently confronting education in terms that can be tackled by a systematic, technological approach. The necessary degree of change, however, has not yet been sufficiently accomplished in relation to expectations. This is as much due to unrealistic levels of expectation and a relatively small degree of financial commitment as it is to the inherent complexity of the problem itself. An unfortunate result of this discrepancy between expectation and accomplishment has been to produce either reluctance or passivity on the part of national bodies and governmental organisations who could and should provide the support and encouragement for the greatly

needed research and development work. It would indeed be unfortunate if the momentum that has developed over the past decade were not sustained since increasing efforts are required if we are to achieve useful solutions.

3. The Computer and Educational Change

The utilisation of computers for instructional and related educational purposes has to be seen in perspective and not simply as the newest technological development in education. In the perception of its worth the computer naturally inherits the failures as well as the accomplishments of previous technological developments, but it is important to distinguish the relationship computing systems have to the problems of education from that which has been the case with audio-visual aids, the new media and programmed instruction.

Computing applications in education can be many and varied, and can be broadly divided into those concerned with the planning and administration of educational services, those where computers are used as tools in educational research, and those where they become resources for learning. In this latter category can be included applications in information storage and retrieval, generation of dynamic demonstrations and displays, extensive calculating facilities, automatic test and assessment activities and the important set of interactive instructional activities wherein students are exposed to computer-controlled systems of learning. The common labels used to describe the interactive use of computers include computer-assisted instruction (CAI) and computer managed instruction (CMI). Such acronyms however do not describe adequately the wide spectrum of possibilities of computer implication in the teaching/learning process and to many observers denote narrow definitions of use. In this report more comprehensive phrases, such as 'computer-based learning', 'the computer as a learning resource' or 'interactive methods of instruction' are used to imply a wide ranging scope of computer uses for instruction, an emphasis on the learning process, and an emphasis on the computer as a fundamental component of integrated systems of learning which may provide the learner with more extended opportunities than hitherto.

Interactive instructional systems require, from the start, that attention be focused on both the teaching and learning processes as well as upon the nature and content of instructional materials. Efforts to utilise computer-based systems have shown that the need for a critical mass of resources to tackle simultaneously the complex issues of instructional method and curricular reform cannot be overstated. Small projects too narrowly conceived and supported for too brief a time cannot be judged a sufficient base from which to launch innovative change. Also learned from the brief history of experience with this technology is the fact that the institutional environment in which research programmes are started and developed has a substantial effect upon their effectiveness particularly in respect of the impact they have upon the training and attitudes of personnel and on the provision of new, improved resources for continuing growth of the concepts and methods. So far systems have either been explored as demonstration and development devices with primary emphasis given to applications that serve mainly to illustrate the feasibility of the approach, or they have been used primarily as laboratory devices to explore interesting and important

basic problems relating to the technology. In this latter respect, it seems safe to say that the major emphasis has been upon the development of specific operational systems, particularly computer software and educational content materials, and that very little research on the basic learning and teaching process which interactive, computer-based instructional systems make possible has taken place. There has been an unfortunate separation of the investigation of computer-based learning from the educational programmes of institutions in a way which has not encouraged symbiotic development of instructional systems. The relevance of research on the teaching/learning process to current teaching problems should be given serious consideration in future planning, and new concepts of faculty organisation may need to be developed in order to build up the knowledge, skills, personnel and systems required to deal with these problems. The question of formulating the appropriate form of organisation and level of effort for the solution of educational problems is not unique with respect to the computer. In recent times we have experienced the same set of problems with respect to audio-visual media, programmed instruction and other technologies.

In this context, it is important to point out two differences between media and interactive computer systems. First, the computer, used as an interactive instrument for instruction, requires that the strategies of teaching and the assessment of learning be considered in the planning and development of these systems. Normally, with audio-visual media, including educational television, the developer of the material has one conception of its use in mind. However, it is nevertheless possible, and usually the case, that other strategies of instruction are employed by teachers so that the materials are embedded into new contexts. This possibility for mismatch between design and use has both advantages and disadvantages, but the development of the media do not require as intensive a consideration of the implications as in the case of a student learning directly from a computer. Second, the growing pressures stemming from the widespread, increasing use of computers in our society in all phases of living make it important for educational institutions to recognise their existence and to relate to their presence. Computers are being used for scientific applications in higher education, where they are being increasingly developed for the purposes of solving problems in engineering; they are also being used for business and management purposes in educational institutions. These and related applications of computers require that higher education take a comprehensive look at computers and the way they may be more efficiently utilised in education. It is essential that educationists take as a matter of urgency the responsibility of defining the goals and uses of computer technology in education, rather than accept this technology as a fait accompli. Important in this respect is the fact that the functions which the computer performs and the materials which are developed for its use in instruction must be the unique responsibility of education. As already stated, the problems associated with this development are unique and complex. The application of interactive systems for instruction is not a trivial transfer of existing information system technology. To assume that the jobs required in the use of computers for instructional purposes can be left to the computer specialist is false and damaging. Important, also, is the realisation that the full and effective utilisation of computers in education requires that they be developed to integrate what are now a group of separate specialties within computer technology. Integrated instructional systems will require aspects of information retrieval, natural language processing,

artificial intelligence, and management information systems to be designed into a single comprehensive system. The important consideration in system design is that it should be flexible and meet the variety of needs of teachers and students. Particularly important is the ability to encourage authors and teachers to use it and to facilitate course development. In this regard, the system should not only provide a means of integrating and organising large amounts of educational material and process this in ways that relate to individual differences in teaching styles and learning needs, but also should develop creativity in teachers and students and encourage imaginative uses.

To accomplish these objectives it is important to have continuing support for co-ordinated programmes of research and development.

4. The Need for Better Planning of R & D Work

The development of the computer as a learning tool over the past decade might be summarised by stating that the activity has been carried out by individuals in laboratories on an inspirational and creative basis rather than upon a complete systems analysis of the requirements to meet the comprehensive needs of educational institutions. Sufficient information and experience has been developed through these efforts to indicate many fruitful as well as many blind alleys; the more fruitful developments need to be further developed and the blind alleys need to be eliminated from the plans of new groups and new countries entering into this area. In order to bring about better planning and development, it would seem appropriate to have international meetings of the nature of this Seminar and from them to emerge programmes and co-operative relationships such that the future will be a more effective and a more productive period for all concerned. Although there is a wish to see a conservation of resources taking place, it is important that we recognise that any larger plans for national and international effort do not preclude the possibility of individual projects and of unplanned activities that might have a contribution to make to the overall development of computers in education.

It is considered essential for the future development of computer-based learning that there should be more planning of the research programmes and financial support than they are given. As already mentioned, one significant aspect of the research that has not been given its due attention in the past is research which looks at questions oriented toward the problems of instruction in the context of ongoing instructional programmes. Most of the research in the past, it seems fair to say, has been research which has been oriented towards specific problems that are examined outside of an ongoing instructional programme but have presumed relevance to such programmes. This type of research needs to be given support as well but should not be the exclusive type of research that is supported and programmed in the larger plans on a national or international basis.

Another area of research that needs further development is that which is designed to look at both sides of the teaching/learning process, namely the instructional aspects and the students learning aspects as an interactive and two-sided operation. Research which relates learning to its avowed function is essential if we are to develop appropriate theories of teaching and theories of learning in cognitive development.

Over the past decade our perceptions of what the computer might do in education have matured; however, it is much easier to talk about what a system might do than to make it capable of doing it. It is even more difficult to define these capabilities in ways that are based upon firm data. Consequently, there is a need to move off a base which has been primarily delivery systems oriented to ask sounder and more far reaching questions. Questions which computing systems could contribute to in a material way and in a way which would be different qualitatively to that in which the psychology of learning and cognitive processes have been developed in the past. The computer can give us a powerful tool for looking at interactive processes in ways that the media and other approaches do not. We need to think of computers as instruments for developing the thinking processes; to serve individual differences in teaching styles and learning needs; and to stimulate creative activities in teachers and students.

Computer-based learning has unfortunately inherited all the problems of education, and revealed them like a microscope showing that the resources necessary, and particularly the conceptual resources, for constructing an important and useful educational enterprise just do not exist.

5. Directions of Effort

A number of areas of study need to be considered seriously in the future development of computers as a learning resource. Some of these are peculiar to the unique contribution of computers to teaching and learning. Others are even more general, for example, the relationship between curriculum content and information about individual learning modes, or that between materials and methods development and psychological research.

The sections that follow summarise the discussions that took place in this Seminar on five main aspects of the specific problem of developing the applications of computers to higher education. These summaries each include a set of broad recommendations that, it is hoped, may provide useful guidelines for policy formation in this field, and which may assist the planning of co-ordinated research and development programmes. It remains but to emphasise here three areas of concern that will affect the development, implementation and acceptance of computer-based learning on a scope and scale that is commensurate with its promise.

A necessary pursuit must be that of the introduction of innovation within established institutions. The whole process of innovation within educational institutions has not been studied in a formal and experimental sense in order to determine effective ways of introducing changes such as those the computer may bring and of modifying concepts and practices of faculties in these institutions. It is vital to involve a wide community of individuals concerned with education in the innovative process itself, and to bring teachers, administrators, parents, students and curriculum and methods developers into a closer collaborative arrangement. Such participation would facilitate the acceptance of the results and benefits of innovative change in the institutions for which it is intended.

Another area of concern involves the response of educational services to the growing and continuing demand for education throughout the adult life of the individual. Efforts are being made to accommodate some of these new needs, in existing institutions, but these appear unlikely to be sufficient and there is a case for a serious investigation of the value of computers as an effective educational instrument for meeting the needs of continuing education for individuals throughout their productive years of employment, and for the upgrading of the necessary technical and managerial skills in a way that has a measurable impact on a nation's economy.

Finally, it is urgent to provide for early exposure of teachers and trainers to the use of computers, and involve them in the further development of this educational technology. Frequently in the past, innovations have been brought into education at the student level before teachers have had an opportunity to experience their effect at first hand. This does not seem to be a desirable approach in terms of the accomplishment of change in a smooth and efficient way. It would seem more appropriate to introduce computing activities into teacher training, and in-service training of teachers, as soon as possible in such a way as to encourage a multiplying effect throughout the education system and to make their utilisation with students more efficient and widespread.

It is not yet possible to answer the question, "In what mode of computer use should research and development effort primarily be invested?", but perhaps it is now possible to obtain a clearer view of priorities in relation to predicted success. The solution of the problems posed, can, we suggest, only come about by preparing coherent national programmes of research and development aimed at optimising and systematising the instructional uses of computers. Such programmes can be improved or developed in the framework of international co-operation. However, co-operation at an international level requires an effort and substantial commitment at the national level.

6. International Co-operation

International co-operation is important now and needs to be encouraged. Basic to the development of international programmes and projects is the development within countries of their own programmes and levels of technology and expertise, but international co-operation can often be most effective at the stage when countries are seeking to establish their own experience. An important aspect of these efforts must be a definition of educational needs and priorities so that specific technological developments can be related to these and become effective agents in the process of educational innovation. In this way decision makers can make more rational assessments of the distribution of their own resources and efforts.

Some suggested ways in which international co-operation might be accomplished are:-

(i) Organisation of meetings for the purpose of bringing together groups, like the one that is convened in Oregon for this meeting, to discuss and take forward ideas and concepts and plans for the future. Simultaneously, special interest groups might

work on specific problems. Meetings of this kind could be appropriately sponsored by an international group once or twice a year.

(ii) Support for scholars and investigators to work with a group in another country for a period of several months or a year. The planning and programming that would be involved in matching particular activities and personnel could be carried out by an international clearing house, although accommodation and financial support would remain the province of national authorities.

(iii) A third mechanism for international co-operation for which there is now some precedent is the joint project effort which involves two or more countries and typically some international organisation.

Two examples of international joint projects illustrate, but do not exhaust, either the pattern of relationships or the purposes of such projects. One is the OECD/CERI joint project on the uses of computers in higher education which involves experiments at a university level in 5 member countries, (France, Belgium, United Kingdom, Japan, Netherlands). It should be pointed out that the mechanism used in this example was one of co-ordinating and relating projects which had already been designed by the investigators in their own country. The second example is the Unesco project in Spain. This project is concerned with the utilisation of computers in teacher training throughout the country. In this case Spain defined its needs and requirements and called on the assistance of Unesco to provide international, professional contributions to the enrichment of the effort. It is hoped that information may be derived from projects of this type that assist in defining methods and approaches that can be utilised in other international efforts.

It would be advantageous if national policies and priorities were established that encouraged international collaborative arrangements among individual investigators. It is at the level of the professional investigator that joint projects may be best developed and designed in relation to their own resources and capabilities, although supplementary encouragement and support by the respective national authorities and by the appropriate international bodies would be no doubt welcome.

International support and encouragement is also desirable for a range of information exchange activities. Some of the needed services could become quite straightforward and attractive to commercial publishers, and require only co-ordination at an international level until they are widely identified and adopted. Other specialist services such as research report libraries, current awareness services, directories of projects and personnel, and assistance on professional visits may require subsidy as well as organisation initially. The general aim should, however, be that each valid activity would eventually find a regular sponsor or means of self-support.

SECTION ONE: AIMS AND MODES

Time and again discussions returned to the basic objectives of education. It is only within this context that the application of computers to education can at all be sensibly assessed. A concern with any educational technology must not be allowed, however unwittingly, to create autonomous goals which conflict with the wider objectives of teaching a subject or with the overriding aims of the educational process.

Again it is seen as essential that systems thinking must be applied right from the beginning in the formulation of any research and development policy to apply computers to education, since the concentration should be on the development of learning systems and on the way in which the computer can best contribute to a technology of education, and not on the development of techniques as such.

Investigation of the possibilities and limitations of computers in education now seems to have gone far enough to enable us to undertake immediate and long-term planning. From the present evidence it is clear that the greatest immediate benefit of computer-based learning systems will be to the education of the post-16 student. This does not dismiss the argument that there may be specific instances where younger children can benefit by interaction with computer-based learning systems, but indicates that the emphasis of national and international research and development activity should be towards the needs of higher and continuing education. Indeed the increasing demand for education throughout the whole of working life suggests that computer-based learning systems should be considered with respect to the whole of the adult population, regardless of level of ability and of attainment.

It is clearly recognised that sufficient experience of computer-based learning systems has already been acquired to point the way in which they can be best developed to satisfy many learning requirements. However, it is also apparent that extensive research and development still has to be accomplished before large-scale implementation in the field can take place. Much more experience needs to be obtained before we can enumerate all educational groups and purposes for which it is an effective teaching/learning medium. For example, it is clear that there will have to be longitudinal studies of the benefits and transfer effects of computer-based learning systems in different subject areas and with populations of varied ability and attainment. Such research and development is likely to prove expensive.

Bearing these general points in mind, the following recommendations are made:

RECOMMENDATIONS

I. In considering the role of computer-based learning systems in higher education, attention should be given to the more general problem of applying computer-based learning systems to the educational needs of the whole of the adult population.

II. Computer-based learning systems should be considered with respect to their capacity to increase both quality of education and quantity of education, i.e. to improve the level of attainment as well as to make the handling of increasing numbers of students possible.

III. The computer should be regarded as an instrument which can assist us to attain desired goals both in fundamental research on learning and in the educational process itself - particularly those involving data processing, decision making, creation of interactive learning environments, testing and information retrieval.

IV. Although it is recognised computer-based learning systems may make possible new teaching strategies and modes of learning and the improvement of old ones, we should nevertheless start with general educational objectives and a clear view of the relevance of the various strategies and modes, and derive the use of technology from these rather than the other way around.

V. The current labels used to describe modes of use, e.g. drill and practice, tutorial, inquiry, problem solving, etc., are inadequate and perpetuate misunderstanding of the real nature of the teaching/learning process. Efforts must be made to replace them by a psychological taxonomy.

VI. Controlled experiments (both in the laboratory and in the field) of the different modes of using the computer should be carried out to determine their effectiveness taking into account factors such as their applicability within different subject areas, and the interaction of motivation, ability and personality of the student.

VII. The effectiveness of computer-based learning systems should be established by very careful evaluation which should extend to long term studies and include measures of the transfer effects.

VIII. Research and development into the nature of computer-based learning systems should be closely co-ordinated with that concerned with improving knowledge of intellectual growth and mental processes.

IX. Research should be conducted to determine the sociopsychological effects that monitoring, managing and motivating implications of computer-based learning may have on the future development of education.

X. Teacher training should include experience of computer-based learning systems to give teachers the opportunity to analyse critically teaching objectives and teaching materials, and to

analyse and use operational data collected on-line. Such experiences may well affect the teacher's preparation in non-computerised teaching. During their working life, teachers should themselves have regular access computer-based learning to improve their level of professionalism.

XI. Access to computer-based learning systems should be made as generally available for student use as are university libraries, and other learning resources.

SECTION TWO: CURRICULUM DEVELOPMENT

A fundamental issue which has yet to be resolved concerns to what extent should the computer be used as an adjunct tool for the classroom teacher, and to what extent might it become the leading edge of a new technology which requires widespread re-organisation of the system of education and changes in the role of the teacher. Both these approaches, which can be considered the extremes of a spectrum of possibilities, provide opportunities and indeed make demands for a reassessment of the nature and scope of the curriculum. As more and more emphasis is placed on the trend from teacher-centred to learner-centred activity so must this reappraisal become more intense. Moreover, extensive use of computers by teachers and students in classroom and laboratory work will produce innovative approaches to learning, new conceptions for structuring the subject matter of the discipline, and creative contributions to knowledge. The impact of computer-based learning will have an important influence on the speed and direction of curriculum development, not least in the area of advanced undergraduate and graduate education.

Over the years the costs of higher education have been consistently increasing and will continue to do so as educational opportunities are being extended to more and more students, including students of lower ability and deficient background. Merely to expand the provision of traditional teaching in expanded but traditional institutions will not be sufficient to stem the pressing social and economic problems of education. New organisational patterns can be expected to emerge in which well-prepared and evaluated learning systems including computer-based systems will play a major role. The development of such learning systems will demand the services of interdisciplinary teams, including experts in the subject area, instructional psychologists, instructional designers and informatics specialists; and these will require assistance from others expert in mass communications, engineering, and business management.

A. Supporting evidence

Recommendations from previous meetings reflect discussion of many issues identified with curriculum research and development.

At the recent OECD/CERI meeting in Japan (Tokyo, June 1970) a number of recommendations were made which relate to needs for research and development in the area of instructional materials.

> "In order better to utilise computers as teaching tools, participants underlined the necessity to conduct further theoretical, experimental, organisational and developmental research in the following fields:

1. Organisation of educational content, i.e. structure of the curriculum material to be taught, on the basis of findings of research into the learning and instructional processes,

2. Development of teaching-learning strategies that allow for the individualisation of the education and provide for an adaptive dialogue between the student and the learning system,

....

4. Evolution of acceptable methods of evaluation of CAI and CMI instructional programmes."

....

At a Unesco consultation on computer-assisted instruction in March 1970 it was agreed that:

....

"C Development of computer-related materials should be pursued in the context of the entire instructional system and co-ordinated with other media and course components

....

"F Extending the base of users beyond one subculture, language or nationality is a much more significant achievement than translation from one computer language and system to another. Important considerations include: language and idiom, cultural knowledge and learning. In addition to the use of experienced local educators as re-writers, in consultation with Anthropologists and Linguists, local trial testing and revision of materials and programmes are essential before cross-cultural use is made of computer-based learning materials."

Other aspects of systematic curriculum development were discussed at a recent OECD/CERI Symposium on computers in higher education (Paris, March 1970), where instructional technology, behavioural science, and systems engineering were all seen to contribute to the production of effective computer-based learning materials.

B. General considerations

At this present meeting, a number of general concerns were expressed in the discussion:

1. It is now necessary to build up the "teachware" to correspond to the software and hardware of computing systems. A set of different techniques and strategies for instruction via the computer needs to be investigated and categorised so that they may be readily applied in different subject areas and situations.

2. Curriculum development should be seen as a multidisciplinary exercise in which the needs and contributions of students, teachers and scholars interrelate with those of experts from areas of supporting technology such as computer and information sciences, psychology, engineering and instructional technology.

3. Initiatives for the production of learning materials should receive some attention, although the considerations will be different for various countries. Will computer-related materials be produced by university professors and distributed by publishers as text books are now? Or will other sources arise: specialised organisations and curriculum laboratories, commercial development organisations, or national institutions?

4. Finally, a whole series of questions emerge which it is hoped more extensive research will help to answer:

In what areas of study and for what kinds of students can systematic curriculum analysis provide completely prescribed courses of study? When should the computer-based learning resource be left open for the student to use as he may decide on the advice of his teacher?

What is the relation between curriculum structure and learning strategy? What findings from research in psychology and education can be used at this time?

What is known about new means for the representation of knowledge, the building of knowledge nets, and the design of processes for interacting with new representations of knowledge? What are the contributions from computing and information sciences, from system and communication sciences and from linguistics?

RECOMMENDATIONS

I. The development of computer-based learning systems should be closely integrated with programmes of curriculum development. The exposure of curriculum planners to the possibilities of computer-based methods will broaden their thinking and enrich their output in many subject fields.

II. The production of tested learning materials should be a major element of any research and development programme on computer-based learning, and emphasis should be given to the development of evaluative measures that exploit the special characteristics of computer-based systems.

III. The role of the scholar in curriculum development must be acknowledged, since it is he who must largely determine and extend the scope and structure of the knowledge base, and explore its internal logic. Development centres should be established within, or in co-operation with, universities and institutes of higher learning, staffed with specialists from a range of disciplines to undertake systematic curriculum development work and its continual evaluation in relation to current educational objectives.

IV. Such centres should also provide individual teachers with advice and assistance in the application of new teaching methods, and in the elements of instructional design. Institutions associated with these centres should devise new options within degree courses and, where appropriate introduce new degree courses for teachers, instructional designers, learning systems analysts, etc.

V. Special assistance for curriculum preparation should be provided by establishing information nets in different subject areas, serviced by computerised automatic indexing, search and retrieval facilities. Curriculum planners and producers of learning materials should document their work adequately and carefully, and add this information to the data base.

VI. Access to such information nets should be made available to qualified learners so that they may build up personal files of knowledge relating to individual needs.

VII. Incentive systems should be devised that encourage curriculum development and maintenance. Professional and economic rewards should encourage potential authors, often working with others in an interdisciplinary group, to develop instructional systems. Recognition of quality work should be a factor in determination of promotion or other advantages. Economic incentives require establishing or improving copy-right regulations for new media, including computer software.

VIII. Satisfactory methods for the long-term sponsorship, publication and distribution of learning materials must be devised which meet the pattern of user demand and maintain commercial viability.

SECTION THREE: HARDWARE IMPLICATIONS

It is most important to set up a balance between technological lead and educational understanding, and to realise that this will not indeed be a static balance. Technical developments will continue despite what we in education might require, with increasing applications in the world of business, banking, airlines, etc., whose requirements on computing services might be considered somewhat similar to those of education. New resources will include: holographic techniques; home facsimile systems; video display units working on low band-width signals; video circuitry for interactive information retrieval, etc. Data transmission systems will be widespread and educational television networks could also be used for data services. Changes in computer technology will provide efficient and rapid time-sharing systems, parallel processing, more efficient use of memory/processor space, and analogue techniques, all of which could enable more sophisticated educational strategies to be implemented.

An area that has to be considered is that of the relationship between business corporations and educational institutions. Education has so far been relatively insulated from the impact of big business, but there may be considerable danger in thinking this will continue to be so. The widespread application of electronic data processing in education could form both the incentive and the point of entry of big corporations. One or two large suppliers may dominate the market in view of the scale of the operation and it is possible that they will not consider compatibility between their products a desirable factor - this may well tie their customers irrevocably. To assure that a large measure of control of the education process itself does not pass into commercial hands, institutional research and development facilities should be maintained under educational leadership. They act as a brake on commercial domination, as a lever to provoke particular action by commercial and industrial enterprises, and as a place in which the users (teachers) can introduce their own ideas and also learn about technology so they become knowledgeable consumers.

Costs are a major unsatisfactory element at this time, although a more co-ordinated market could bring savings through the production of devices which have general applicability and hence which justify larger and more economic production. This has already occurred for many computer components. It is important when considering costings not to place too much emphasis on current figures since they have decreased rapidly in the past few years. Analyses of the economics of technology should be made with a frame of reference that will apply in five to eight years time. It is further necessary to consider the total cost concept, using cost over useful life rather than initial capital cost as the main criterion. Amortisation practices differ and supplementary expenditures such as those involved in training personnel and in supplying secondary services vary according to the particular location and application involved.

The provision of performance specifications, especially those of the man/machine interface, is a problem common to the whole range of audiovisual devices for educational technology, where much deep study is required. The ideal will be functionally "transparent" interface, one that does not intrude into the learning process. A further consideration must be modularity and the concept of inter-changeability with other components for audiovisual learning and information retrieval, e.g. common unitised media or storage devices. Aspects of maintenance and servicing must be considered in relation to performance; efficiency is gained through standardisation. Built-in redundancy is essential since alternative means of providing the educational service must prevail in the case of a failure in a minor element of a machine system.

Reliability must be given priority in design: either mean-time between failures should be large or the mean-down-time should be a matter of seconds. Another aspect of design should be that of planned obsolescence, or rolling development, whichever way you care to look at it (in the telephone system new developments must contain all that has gone before). Whenever educational hardware has to be replaced, teachers should not have to discard or recast all the educational content materials. It is most important that the heavy investment in expensive conceptual and intellectual work on curriculum carries through into new system designs. Control at the operational level must remain in the hands of the educationist and not be built into the technology. There is a need for flexibility to permit teachers to insert their own material and/or to select from a wide choice of inventory with some opportunity to elaborate or modify.

A. General Considerations

A number of polarities in the development of computer-based learning systems were identified in the course of the discussions, for example:

A spectrum of uses ranges from direct interaction with students in some instances, to indirect communication with teachers in others.

Large dedicated computer based learning systems can be contrasted with small scale localised systems or systems optimised to provide a specific service.

Computer-based learning can be considered as a complete activity in itself or as an activity complementary to conventional classroom instruction.

Systems for application purposes may differ widely from research (a research project might incorporate complex sophisticated equipment which could never be justified for a wide ranging practical application.)

It is apparent that technological capability is far in advance of understanding of how to use that technology. The technologist's desire to do something with his equipment should be diverted into giving the educator proper service and refined devices. In addition, the natural pragmatism of the educator should be tempered by a willingness to apply the concepts of systems design in order to work more effectively with the technologist.

When considering the hardware implications of the application of computing techniques to the educational process particular care should be taken to assure that:

1. Total systems characteristics should facilitate the widest possible dissemination of the educational materials which are produced.

2. Terminal devices should be available equally to serve students in the course of their learning, teacher/authors for the production of instructional materials, and those concerned with more general aspects of course development and analysis.

B. Supporting Rationale for Recommendations

1. Current hardware is not fully adequate for widespread operational use of computer-based learning, particularly from the standpoints of performance and cost.

2. Attention to both large and small systems must be addressed because it is not yet clear that either will gain predominance in the foreseeable future.

3. Hardware requirements and guidelines given the status of international approval could stimulate increased commercial interest and activity, which in turn would stimulate usage, and facilitate maximum compatibility between systems.

4. These requirements and guidelines would also help limit substantial commercial activities, for example, the introduction of computer-based learning systems seriously limited in scope and not expandable. Commercial firms would have the information needed to channel their resources in practical directions, and potential users would be better informed about expected capabilities.

5. Actions concerning computer-based learning systems at national and international levels provide the best assurance that developments will be co-ordinated with actions and plans in related technologies, for example communications and television.

In the light of these general considerations, the following recommendations are made, which we suggest should be funded at a national level and wherever possible should involve international co-operation:

RECOMMENDATIONS

I. An initial and continuing assessment should be made of the current and near future hardware requirements for computer-based learning systems. This assessment should apply the general considerations described previously, and should recognise the realities of the business world (manufacturing and marketing) and implementation. The result should be an identification of specific requirements, preferably with acceptable price ranges stated.

II. An initial and continuing assessment should be made of hardware currently in use or being developed for computer-based learning systems to assure a full recognition of the "state of the art" and properly to determine which of the specific requirements have already been accomplished. This assessment should be used as a guide in determining the support given to a hardware development programme.

III. Specific development projects should be funded for hardware requirements not considered as satisfied through the above investigations.

IV. At an international level the following activities are suggested as suitable subjects for co-operative projects:

(a) Testing and evaluation of existing total or partial computer-based learning systems.

(b) Thorough evaluation of specific hardware to include human engineering aspects.

(c) Joint actions with those developing communications systems (for example, use of satellites).

(d) Establishment of international standards to improve communication systems and to effect maximum transferability between hardware systems.

V. As a preliminary activity OECD, or some suitable international agency, should immediately commission a survey of the range of hardware devices considered to be necessary for the implementation of computer-based learning systems, with some indication of their current states of development.

SECTION FOUR: SOFTWARE CONSIDERATIONS

The variety of needs which educational uses place on computing software is very great. Most of the interactive computing systems operating today serve the needs of only a segment of the educational user group. Selections from a catalogue of general-purpose languages, such as those for scientific or business computing, simulation and string processing, can satisfy some educational purposes, but the requirements of instruction by computer need to be met by systems designed especially for instructional purposes. Close co-operation between teachers, educational systems specialists and software designers is desirable for developing these special features.

A useful approach is to have a central system development group work with a variety of users so as to acquire a broad base of experience servicing different kinds of instructional strategy and the special requirements of different subject matters. Under these conditions a system can be developed to meet a number of real requirements and in a way that encourages compatibility between different applications.

The development of computer-based instructional systems is still at an early stage; a variety of approaches to the solution of software problems should be encouraged. The most effective strategies to employ in instructional systems are not yet established, and some of the instructional approaches used so far have been too much determined by characteristics of software currently available. Ideally, the programming that has to be done should be determined by the course development staff in the light of the learner's needs.

Co-operation and exchange among developmental projects, although working in different locations and on different computing systems, can reduce needless duplication and encourage broader use of new software ideas. It is important that new modules and functions should be documented in such a way that they can be easily transferred to other systems and readily used by others than those by whom they were developed.

Recognising that both large and small computing systems will be used in education, it is necessary to support the development of appropriate software for each: large systems will provide variety in languages and facilities and provide extensive file handling and other educationally relevant capabilities; small systems are valued for their accessability and portability. Access to large systems by remote users, however, is becoming more possible and more reliable, and the associated software more readily modifiable to meet the needs of individual users. At the same time, small computers are being associated with larger systems in a way which removes most of the argument about system size. Each of the small computers can draw upon the larger processor to work with extended data bases, to call upon specialised software, and to perform large scale calculations which would consume too much processing time on the small local computer used alone. Each small computer still is available to work separately.

All research and development projects and most applications in college settings should remain flexible and avoid restrictions on users which arise when the language and system are built around too small a number of instructional requirements. New pedagogical paradigms should be encouraged and incorporated in software modules convenient for author use and for use by other authors not involved in their original development.

The introduction of automatic information processing, flexible information structures and convenient communication links is more likely to facilitate innovation and change in education than the computerisation of ineffective practices. As suggested in the section on curriculum development, teachers ought to be encouraged to develop new approaches to the teaching of their subject matter. For example, they might use problems to be solved, simulation or some other thought-provoking activity to develop the interest and participation of students. The software should encourage this type of teaching and make it as convenient to do as simpler things.

In view of these considerations mentioned above, the following recommendations in respect of software development should receive priority attention:

RECOMMENDATIONS

I. Research and development projects should have as one of their purposes the investigation of new software solutions to instructional problems.

II. In order for the full capabilities of automatic information processing for instruction to be realised, programming languages should be developed for design of instructional procedures and displays that provide a wide variety of options. On the other hand, languages and procedures for the management of instruction should be unambiguous to the teachers and easy for them to use.

III. The development of integrated software systems should be from a broad base of experience drawing on the full spectrum of capabilities of computing systems and development projects.

IV. The current state of the art in teaching and the meagre knowledge that exists with respect to instructional methods suggests that the computer may serve to develop the thinking of teachers regarding the ways in which they want students to interact with learning resources. The unique capabilities of a computer should be made clearly evident to teachers and the software should make these features readily useable by them. The encouragement of exploration by teachers of new methods of teaching and new aids for learning is a critical requirement for computer-based instructional systems.

V. The implementation of software development should be seen as a co-operative, multi-disciplinary effort, and should be facilitated by a number of means, including workshop meetings involving appropriate staff from co-operating projects. This is particularly important in the immediate future before competing systems become too entrenched.

VI. There should be national and international encouragement for the development of guidelines, particularly for documentation of programmes and procedures, to facilitate the transfer of new software from the originating project to others. Guidelines should reflect the best thinking on the preparation and maintenance of user-oriented materials.

VII. International professional associations such as IFIP should be encouraged to promote discussion and information exchange through existing channels and meetings, and also to establish a software interest group concerned with computer-oriented educational technology. The composition of the meetings and the group should be interdisciplinary and multi-national, including contributors from such areas as education, psychology, computer and information sciences, engineering and linguistics.

SECTION FIVE: INFORMATION EXCHANGE

Nearly every project newly engaged on research and development into computers in the instructional process begins with a review of what has been done and what else is in progress. Growth in this area has been so great in the last decade that no longer is it possible for any one project to justify a comprehensive survey for its own use. Maintenance of a current and comprehensive library of international scope is far beyond the resources of individual projects for collection, translation, abstracting and interpretation.

Provision of an effective information exchange should be assumed by international organisations such as OECD, Unesco and perhaps IFIP. Only these kinds of organisations can assemble the necessary talent for selection and interpretation of the valuable work apart from the nearly useless. Increasing numbers of technical reports, theoretical papers, research notes and opinion statements are being placed in limited circulation each month. Some information functions crossing national boundaries can be handled well by publishers of international stature but they could benefit from sound direction by some group of professionals; eventually most information exchange functions ought to be placed on a paying basis, but initially some subsidy is likely. Individual governments and international sources of funds might support fellowships, interpretive summaries and documentation. Individual projects might pay for exchange of documentation and personnel of particular advantage to them. Most of the publications activity can be supported by subscriptions through commercial publishers.

Along with exchange of research documents, one should plan for exchange of information about projects interested in interchange of personnel. Such information files could also be arranged to advise about opportunities for professional visits when on a trip or in attendance at a conference.

The general recommendations have included advice about an annual conference, working groups and personnel exchange through fellowship programmes. These mechanisms should be, it is hoped, amplified and extended by the specific recommendations for information exchange that follow. Brief indications of the options and opportunities available for initiation of each service are given. Elaboration of these options and action recommendations should be a first order of business for the meeting of an international planning group assembled to organise mutually beneficial activities regarding instructional use of computers.

RECOMMENDATIONS

I. An international reference library of research documents, project descriptions, instructional-material descriptions, etc. (all available in French and English at least) should be established.

Two options exist to begin with:

(a) Education Resource and Information Center (ERIC) in the US, especially the Clearing House on Educational Media at Stanford University, collaborating with a similar European centre providing translation.

(b) Files at OECD's CERI or IFIP's IAG, or any project which has a sizeable library of international literature and facilities for translation.

II. A bulletin devoted to computer uses in education should be published on a regular schedule and distributed widely.

This might be based on:

(a) Newsletter of the ERIC Clearing House on Educational Media (USA)

(b) Computer Education (UK), with an additional instructional uses section.

(c) Bulletin of the ACM Special Interest Group on Computer Uses in Education (USA)

(d) A new bulletin or "Letter journal" to be established by OECD-CERI, IFIP or a similar organisation, probably in co-operation with an international publisher.

III. Current and interpretive bibliographies and surveys, at times highly selective, should be distributed with a periodical or on request.

The authors might be:

(a) Library and bulletin staff implied by Recommendations I and II.

(b) Experts commissioned by the institution or agency sponsoring the library and/or bulletin.

(c) Contributors to an annual conference selected on the merit of their presentations.

IV. A current awareness service, distributing selectively to projects and individuals according to interest profiles provided by them as users of the service, should be initiated.

Three factors will affect its success:

(a) Preparation and effective use of an expandable set of descriptors.

(b) Prompt and reliable classification of documents.

(c) Reliable data on use and satisfaction with which to assess and improve the system.

V. Other arrangements for exchange of documents and materials (and perhaps personnel) directly between two projects or individuals should be provided.

A central organisation can facilitate interchange by providing:

(a) Directory of projects and individuals giving interest profiles and mailing addresses.

(b) Assistance in making arrangements for personal visits and for exchange of personnel.

(c) Encouragement for government-sponsored fellowships designed to bring in scholars from other countries.

VI. Assistance on planning professional visits during trips, especially in association with meetings, should be provided.

(a) Whatever information service may be established (library or bulletin or whatever) it could also maintain a list of places to visit and information about suitable times, duration and persons to contact.

(b) A special announcement of places to visit nearby a Conference site could be worked out with affected project directors who are willing to take a small group of visitors before or after the Conference.

(c) The breadth of experience available through Conference site visits is broadened if Conference locations rotate among interested countries; bringing in a Conference also encourages new activities at each nearby host site.

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LIST OF DOCUMENTS PRESENTED DURING THE SEMINAR AT PORTLAND (OREGON)

(Joint Project CERI XI)

CERI/CT/69.02	DONIO J. Present situation and development trends
CERI/CT/69.02 Annex	Utilisation of computers in education in the USA (Written by the SECRETARIAT)
CERI/CT/70.34	JONES A. Evaluation and testing of knowledge
CERI/CT/70.36	de KLERK L. Some remarks on our experiences with the use of coursewriter III in C.A.I.
CERI/CT/70.37	Report on the final meeting held on 21st March, 1970
CERI/CT/70.60	Le CORRE Y., JACOUD R. Computer-assisted instruction
CERI/CT/70.61	MOLNAR A. The computer and curriculum analysis
CERI/CT/70.62	ZINN K. Requirements for programming languages in computer-based instructional systems
CERI/CT/70.63	List of participants